SOME WORK ON MARINE PHYTOPLANKTON IN 1919

By
W. E. Allen
Scripps Institution for Biological Research of the University of California.

On September 1, 1919, efforts to use tow nets for quantitative work with phytoplankton in the La Jolla area were abandoned and the resources of the Scripps Institution available for such work were temporarily concentrated upon collection and study of a series of catches made from our pier by the measured water method at intervals of twelve hours. These catches were taken by the simple procedure of dipping water from the surface of the sea at a point about one thousand feet from shore and immediately pouring it through a filtering net made of number 25 bolting silk. This net was made in the form of a funnel into the small end of which a bottle or other receptacle could be tied. After filtration catches were preserved in formalin for quantitative study at convenience.

Quantitative studies consisted in roughly approximate identifications of the species present and in an enumeration of representatives of each found in a certain fractional part of a catch mounted in a Sedgwick-Rafter counting cell. Necessary aids to this work were a Whipple eyepiece micrometer and a mechanical stage. Records were later assembled in the form of tables which were studied with reference to occurrence and prominence of species in the locality at the time and through the period of observation.

It is interesting to note that the locality in which this work was done was much farther south than points at which extensive studies of phytoplankton have been made in Atlantic waters, i. e., it is in about the latitude of Northern Egypt. Furthermore the fact that catches were made regularly and continuously for months at intervals of twelve hours (8 a. m. and 8 p. m.) marks the series as somewhat different from most other groups of catches of marine plankton material.

Surface water temperatures taken at the time of making the catches showed a range from 23° C. in August to 13° C. in December, but the range within the limits of discussion of this paper was from 208° C. in September to 13° C. in December.

Although there are other plants which take some part in synthetic activities in the open sea and although dinoflagellates of many kinds are generally analytic rather than synthetic in character, it has appeared from preliminary studies of marine plankton in the Southern California region that the groups most promising for quantitative study as synthesizing organisms are the diatoms and dinoflagellates, (or at least the armored dinoflagellates). There seems to be no reasonable doubt that these two

groups of organisms are on account of their small size, large numbers, rapid growth, facile reproduction, wide distribution and cosmopolitan character peculiarly favorable objects for quantitative study especially since they seem to be the most easily and continuously accessible of all marine organisms.

Both groups show rhythms and pulses of production which are more or less evident in each month of the year. Such rhythms and pulses are, however, characterized by changes in prominence of particular species according to season and according to certain other variable conditions.

For convenience in the present discussion a pulse may be defined as a marked increase in numbers of organisms which extends over a period of three or more days before decreasing to or near the numbers found at its beginning. In this four month period there were five such pulses of diatoms and four of dinoflagellates. In both groups they were unevenly distributed in the period. The records show that out of four times possible for coincidence of pulses of the two groups there were two close approximations to coincidence. This, of course, indicates that both groups of organisms are sometimes favored by the same stimuli to production.

But it is true that some other evidence indicates different possibilities, e. g., there were fourteen cases in which a catch of diatoms was more than three times as large as either the catch preceding or the one succeeding it and there were fifteen such cases of dinoflagellate catches. Out of fourteen chances for coincidence of such catches in the two groups only four occurred, a fact which leads one to think they may be to some extent mutually deterrent. This view gains support from the fact that catches distinctly low in numbers as contrasted with those catches nearest them show no coincidence in five chances although we might expect that there would be coincident absence in both groups if both were similarly responsive to changes in local conditions. In view of such considerations one seems to be driven to the provisional assumption that plants in the open sea like those on land may sometimes find such generally favorable conditions that widely different types may live and thrive together without prejudice but that usually some factor has given one form a better opportunity than another which may be used to the detriment or to the complete exclusion of that other.

The above mentioned exhibits of presence and absence are still more suggestive in regard to the perennial assumption that marine organisms are uniformly distributed through considerable areas of marine waters. A catch markedly larger than both of those at twelve hours from it or a catch markedly smaller than both surely indicates that distribution is not uniform in the given area.

Since catches were taken rather early in the day and early in the night the records were examined for evidence of greater productivity in light

or darkness. In October and November, two months out of the four, about four-fifths of the larger catches were made in the morning and in the other two months there was not much difference. So far as this limited evidence goes it favors the view that growth and reproduction occurs most vigorously at night, as might be expected from our general knowledge of distribution of plant activities in the twenty-four hours.

Although many species of diatoms and dinoflagellates may be found in the Southern California region there are not many which are ever very prominent or numerically important and there are very few which are frequently and continuously thus important. Since most of these can be identified fairly well under ordinary conditions of examination, statistical study is not seriously hampered by the requirements of taxonomy.

For most purposes it is best to study the distribution of diatoms and dinoflagellates as separate groups. Thus considered the following points may be noted concerning diatoms: Some representatives of the group were to be found throughout the period although distribution was very irregular. Large numbers appeared in the last three months of September thus producing an autumnal maximum similar to those noted in European waters.

In connection with this maximum I was interested in noting that for two or three days previous to its inception there had been rather strong and constant currents from the north. I also noticed that large numbers of mackerel came to the vicinity of our pier in the latter part of August and left about the time that the great increase in diatom prduction began. Whether these points were mere coincidences or whether they had significant relationship to increased diatom production, I have no means of knowing

Forty six species of diatoms were recorded in the four months but only twelve of these were readily identified although fourteen were usually approximated, i. e., confusion limited to only one or two other forms. These included most of those of numerical importance. Eleven forms were found to have been represented in the most abundant five in one or more months. Five of these belonged to the genus *Chaetoceras*. They were mostly rather small species and difficult to identify.

Detailed study of the records has clearly shown the important fact that when there is increased production of the most prominent forms there is also increased production of the less prominent forms and an increase in the number of different forms. Such facts naturally lead to the assumption that conditions favorable to high productivity of diatoms in the sea affect a large number of forms in the same way. They also lead to the inference that determination of the species which shall lead in production is largely due to biological factors such as rapid multiplication and vigorous development.

As to the dinoflagellates I may say that they are usually much fewer in numbers than are the diatoms. Otherwise the general features of their distribution are not greatly different except in the periods of maximum production. In the last four months of 1919 the greatest numbers were produced in November but there had also been some heavy production in August several weeks before the maximum production of diatoms.

Thirty-seven forms of dinoflagellates were recorded eight of which were fairly easy to identify. Usually satisfactory identification of twelve forms could be made and these included most of those showing numerical importance. Six easily identified species were found amongst the five most numerous in one or more of the four months. Two of them belonged to the genus *Ceratium*.

Two of these most prominent species deserve special mention because of their connection with the phenomenon called "red water." *Gonyaulax polyedra* Stein has at various times been mentioned as responsible for extensive areas of "red water" in Southern California which have attracted especial attention because of the bad odor where it was washed upon the beaches and because of the large number of littoral animals killed by it and then stranded upon the beaches. The brownish or reddish color of the water is due merely to the vast numbers of these small organisms present in it. The destruction of littoral animals is usually said to be due to products of decay after death of such quantities of the microscopic organism. But it is possible that the living *Gonyaulax* is also poisonous to animals. In the last three or four years *Prorocentrum micans* Ehr. has been more often detected as a cause of "red water" than has Gonyaulax but no cases have been reported in which littoral animals died as a result of its presence. It is noticeable that in "red water" areas (some of which extend for miles in open water) very few other organisms, large or small, are found amongst those which cause the discoloration.

Several different kinds of dinoflagellates cause the appearance of water called "phosphorescence." More or less glow of this sort may be observed in waters of our section at almost any time of year although not continuously present. At times there are present in the water sufficient numbers of individuals of this sort to cause at night a glowing pathway where fishes stimulate them by swimming through.

A more detailed report of this work in 1919 is awaiting publication in another place. Its conclusions may be briefly stated as follows:

First, the measured water method seems to be by far the best to use for a *standard* method and the surface level to be the best for a *standard* level of collecting for quantitative study. Other methods and other levels should be regarded as special methods more or less supplementary to the standard.

Second, there is evidence that drift currents have pronounced influence on phytoplankton production at our pier.

Third, large numbers of phytoplankton organisms respond to conditions of production favorable for any one.

Fourth, it seems probable that some of the more prominent forms may be useful as indicators of certain conditions in the ecologic complex.

Lastly, it is evident that the problems of the ecologic complex of the sea are fascinating as well as intricate and baffling and that in many ways good returns are sooner or later to be expected as the results of time and energy expended in study upon them.